ABSTRACT

System concepts for network enabled image-based ISR (intelligence, surveillance, reconnaissance) is the major mission of Fraunhofer IITB's applied research in the area of defence and security solutions. For the TechDemo08 as part of the NATO CNAD POW Defence against terrorism Fraunhofer IITB advanced a new multi display concept to handle the shear amount and high complexity of ISR data acquired by networked, distributed surveillance systems with the objective to support the generation of a common situation picture. Amount and Complexity of ISR data demands an innovative man-machine interface concept for humans to deal with it. The IITB's concept is the Digital Map & Situation Surface. This concept offers to the user a coherent multi display environment combining a horizontal surface for the situation overview from the bird's eye view, an attached vertical display for collateral information and so-called fovea-tablets as personalized magic lenses in order to obtain high resolved and role-specific information about a focused area-of-interest and to interact with it. In the context of TechDemo08 the Digital Map & Situation Surface served as workspace for team-based situation visualization and analysis. Multiple sea- and landside surveillance components were connected to the system.

1. INTRODUCTION

1.1 Motivation

The complex tasks of military forces in the today’s mostly asymmetric warfare on the one hand and on the other hand the availability of more and more real-time sensors and other sources to gain information about the theatre of interest demand a very comprehensive situation display for decision making. Such a display should offer a not too detailed view over the total area of interest as well as a specifically detailed view onto the current focus of interest without losing the general overview (focus plus context). Preferably such displays should support decision making in small teams. It is obvious that single display solutions will not optimally satisfy this demand. In today’s command and control environment various specific display types are used: from the personalized tablet PC over desktop solutions to screen projections and video walls. What soldiers are missing is sufficient coherence between these display types. The »Digital Map & Situation Surface« offers a solution concept to combine fixed and mobile, large and small scale displays coherently to a team-oriented multi-display workspace for network enabled situation analysis.

1.2 State-of-the-art of science and technology

For building a team workspace for situation analysis as motivated above, currently mainly large scale displays, e.g. wall projections, LCD-displays, are used in order to provide the team with an overview of the current situation. During the past view years many interesting interaction technologies, e.g. multitouch have been developed in order to make interaction with such displays more intuitive. However, the resolution of large scale displays, which are commercially available, still is not high enough for detailed map and situation analysis. In order to increase level of detail at a certain point of interest the user has either to change the zoom level on overview visualisation or use special software tools e.g. for displaying details in a separate window. In both cases parts of the overview visualisation is temporarily lost, either due to zooming or due to occlusion by additional windows on the screen.

Newer approaches integrate multiple displays in order to realize regions with high resolution integrated in large screens [1], [2], [3]. However, in these approaches either areas with high resolution are integrated at a static location [2], [3] or technology used for tracking mobile devices is limited [1]. See also [4] for further discussion.

The idea of using mobile viewing filters, which provide local different views onto the application lying underneath, was also published in [5]. With their approach it is possible to view and manipulate different aspects of a scene displayed on
a large screen without the need to change the visualization on the whole screen. Another popular work in HCI research is that of [6]. They used active and passive lenses in order to provide personalized views onto a tabletop display.

Our approach for a team workspace for situation analysis goes beyond the above mentioned ideas from literature. It provides displays for overview visualisation for all team members and at the same time allows for detailed analysis of data in mobile personal areas. Our concept of a Digital Map & Situation Surface is described in detail in the following section. In [7] we showed the potential of our concept for improving workflow in an emergency operation centre [8]. In this paper the focus is on reporting about experiences made during an exercise in military context.

2. MULTI-DISPLAY WORKSPACE “DIGITAL MAP & SITUATION SURFACE”

2.1 System Concept

The user interface consists of three types of hardware components. The first component is a horizontal tabletop display which is realized by back projection and measures 90x120 cm (see Figure 1). A second large display is attached perpendicular to the tabletop and provides space for displaying information on objects which can’t be adequately displayed on the horizontal display for a group of people. Such extra information may include images without any georeference, text, or the video stream of a surveillance camera installed at a marked location.

![Figure 1: Digital Map & Situation Surface consisting of one tabletop display (1), one vertical display (3) and multiple mobile Fovea-Tabletts](image)

This setup itself is not new, and similar constructions are used e.g. by [9], [10]. However, as already mentioned in a study on the use of large displays in automotive design [11], “...the story is about interaction, not displays”. In contrast to conventional tabletop systems, with our approach multiple small displays, so-called Fovea-Tabletts, can be placed at arbitrary locations on the tabletop in order to provide personalized views into the information space with high resolution. In the simplest case only the resolution of the visualization is locally increased as shown in Figure 2.
Figure 2: Gain of resolution on Fovea-Tablets

However, each Fovea-Tabletts provides additional tools, which can be used for interaction on tablet-PCs independently from visualization on tabletop display. Zooming on Fovea-Tabletts independently from tabletop e.g. allows for analyzing details while at the same time maintaining overview on horizontal and vertical large scale displays.

Fovea-Tabletts can also be disconnected from tabletop workspace in order to use them as mobile PCs, e.g. to collect new or analyze data. This multifunctional usage of tablet-PCs reduces the gap between personal and group interaction, since a user just needs to put his/her Fovea-Tablett onto the tabletop in order to “jump in” and be involved in the discussion while maintaining his/her personal information environment.

In order to determine location and orientation of Fovea-Tabletts on the tabletop we use a marker based approach where mobile devices are tracked in image sequences which are taken by a camera from behind the semi-transparent projection surface (see [4], [7], [8] for further details).

2.2 System architecture

The system architecture of the Digital Map & Situation Surface is shown in Figure 3. It is structured in three layers, namely data management, communication and presentation layer.

The core of the data management layer is a UMN MapServer [12], which serves as storage for geographical related data. The latter can either be basic geographical data like maps and satellite images or data from external data sources which need to be stored temporarily. Data from external sources can be made available for higher layers either via the MapServer or directly in an external GIS-database. As interfaces for external GIS-databases web map service (WMS) and web feature service (WFS) are supported.

The communication layer captures two different kinds of data streams. On the one hand, information from data management layer to visualization components in presentation layer is transferred via OGC-web services (WMS,WFS). On the other hand, control data streams required for coupling different input and output devices of the Digital Map & Situation Surface are routed by a so called I/O-server.

The presentation layer provides visualization of data adapted according to the type visualization component the instance is running on and takes input from the user. As input devices currently a mouse is used for the table and a pen for the Fovea-Tabletts. For the software components in presentation layer we distinguish between the GIS-viewer and “additional components”, while the GIS-viewer is an in-house development and “additional components” are third party applications. The GIS-viewer is able to display data with geographical reference like maps, satellite images or tactical symbols and geo-referenced icons. Additional third party applications can be easily integrated, e.g. for displaying information on the vertical monitor. Only an appropriate I/O-Client needs to be implemented in the third party
application in order to be able to respond to user input received by one of the devices of the Digital Map & Situation Surface. Component

3. EMPLOYMENT IN TECH DEMO

3.1 Technology Demonstration 2008

Between 25th August and 5th September 2008 the Technology Demonstration TechDemo08 took place in Eckernförde (Germany). To avoid additional organisational efforts, reduce costs and achieve synergetic effects, TechTemo08 included both, trials for ISR against terrorist attacks belonging to the NATO’s Defence against Terrorism (DAT) programme, and the harbour protection trials 2008 (HPT 08).

Goal of the NATO’s Defence against Terrorism (DAT) programme is to develop new, cutting-edge technologies to protect troops and civilians against terrorist attacks [13]. These technologies are aimed at preventing the kinds of attacks perpetrated by terrorists, such as suicide attacks with improvised explosive devices, rocket attacks against aircraft and helicopters. Due to the urgent nature of the threat, most projects launched under the programme are focused on finding solutions that can be fielded in the near future. In practice the DAT programme of work is focused on different areas where it is believed technology can help. Goal of the TechDemo08 NATO was to test new harbour protection technologies [14].

The Harbour Protection Trials 2008 (HPT 08) had the objective to protect harbours, anchorages and approaches from attack by terrorists using small surface/subsurface craft, slow low flyers, divers and IED/mines against military vessels, commercial shipping and port infrastructure [15]. The trials were intended to test new technologies for countering
asymmetric threat in the complex environment of a harbour and its approaches and to thus continue and, at the same time, refine the trials conducted in La Spezia and Taranto in the years before.

With TechDemo08 three lead nations – Belgium, Germany and Italy – combined their efforts to test and validate new surveillance technologies in a harbour environment [14]. The objective was to evaluate the systems’ effectiveness in searching, identifying and defeating any potential terrorist threat or intruder approaching the harbour. The goal of the demonstration was to harmonize the DAT POW initiatives and provide a comprehensive approach for the protection of NATO forces, equipment and critical infrastructure. It also aimed to present new technologies and highlight possible contributions by NATO Partner countries.

3.2 System Network Architecture

The following image shows the network architecture of TechDemo08 which was derived from the architecture of MAJIIC (Multi-sensor Aerospace-ground Joint ISR Interoperability Coalition). It includes reconnaissance sensors, image exploitation stations, joint data bases, and systems for situation analysis.

![Network Architecture Diagram]

Figure 4. Rough Overview about the TechDemo08 system network architecture.

Airborne, maritime, and ground assets delivered images, videos, and tracks which build the data base for observing the camp and its environment. Image interpreter analysed imaging data on exploitation stations and described interesting
scenes in reports. To assure a fast and STANAG conform data exchange between the different systems coalition shared data bases (CSD) were integrated.

Basis for a joint data collection and exploitation was the coalition exploitation plan (CXP) which provided a daily guidance for a theatre-wide ISR resource employment. There was one CXP for the wide area airborne assets and one for the assets which were operated local to observe camp and harbour permanently and in real time. Local assets were e.g. a surveillance balloon with imaging sensors on board and the maritime LEXXWAR system which provided tracks with associated videos.

Based on reports, tracks and additional information situation data were derived. In the operational cell the situation was analyzed, based on the derived situation demand was determined and the effort of sensors and military forces was ordered.

3.3 Digital Situation & Map Surface as a workspace for situation analysis

Located in the operational cell the Digital Map & Situation Surface was the workspace for the situation officer. He performed situation analysis to get a general idea about the actual situation. This again was the basis for further mission planning.

3.3.1 Data access

During TechDemo08 the accesses from the Digital Map & Situation Surface to different kind of data was assured. Different map data was offered. These data and gave a static overview about the scene of interest and were stored in the map server’s file system or on a GIS-Server which could be reached via WMS (Web Mapping Service). Via CSD the following reconnaissance data were available:

- CXP (collection exploitation plan)
- reports with different priorities which described a regions of interest in textual form
- analysed images of regions of interest
- video sequences of regions of interest
- tracks from different sensor systems, whereby tracks are real time data which contain the following object information: coordinate, classification, speed and moving direction
- tracks from blue forces (own forces)
- situation information derived from reconnaissance data

To make these data available connections to external systems (GIS-Server, CSD) had to be realized (see Figure 4). These connections were implemented via the data management layer (see Figure 2). With a CSD client which is an interface to CSD itself different data types (images, videos, tracks, reports, situation information and CXPs) could be obtained. The CSD client enables to restrict data queries by data type, a geometric description, and the acquisition time. After a CSD data query the CSD data were transferred to the Digital Situation & Map Surface and temporarily stored on its map server. Now the data could be displayed in an appropriate way.

Additionally video streams from the surveillance balloon and the videos of the maritime LEXXWAR system were available in real time. The access to these video streams was realised by a direct connection. Hence the use of high dynamic data was enabled which is indispensable for fast scenarios like terror attacks.

If additional data were necessary the situation officer could order further data from all available reconnaissance assets with help of so called dynamic information request (DIR). DIR was also used to change the observing area of the surveillance balloon’s sensor.

3.3.2 Data visualization

Data request and configuration of data visualization were carried out on a Fovea-Tablett® (see Figure 5). On the right hand side is the tool bar which enabled the situation officer the access to a tool for

- changing the map layer
- creating CSD requests
- creating dynamic information requests (DIR).
When high dynamic data like tracks and situation information appeared at the Digital Map & Situation Surface they were displayed suddenly. When other data types (reports, images and video sequences) arrived at the Digital Map & Situation Surface the CSD button on the left display side started blinking. If data with a high priority arrived a red exclamation mark additionally appeared beside the CSD button.

Figure 5. View of the Fovea-Tablett® display with north arrow (upper left), CSD-button (lower left), tool bar (right side), and symbols representing reports with different priority.

Figure 6. Bounding box of an image and menu with different image display options.
When the situation officer selected the CSD button all available report, video, and image data were offered to him in a file box. Now he could choose which data he wanted to look at. Chosen data were displayed first symbolic. Reports were represented by a report symbol (see also Figure 5), images and video sequences by their bounding box (see Figure 6). When selecting the symbolic data representation a menu was opened and the situation officer could decide between the following data representation:

- “Show on vertical monitor” shows the image or the report text on the vertical monitor
- “Compare on vertical monitor” compares the chosen data with data already displayed on the vertical monitor
- “Show / hide this image” displays the image on the horizontal display (table display and / or Fovea-Tablett®) or hides it
- “Disable” makes the symbolic representation disappear

Tracks and situation information are high dynamic data with high priority and were therefore displayed without request. Both information types were visual coded using APP-6A tactical symbols. Additional information like speed, track producer (e.g. LEXXXWAR) or attached video data could be displayed on the vertical monitor if necessary. Figure 7 shows a situation displayed on the Digital Map & Situation Surface during TechDemo08.

![Figure 7. View to the Fovea-Tablett® on the Digital Map & Situation Table during TechDemo08.](image)

Video streams from the surveillance balloon and the LEXXXWAR system were permanently available if their sensors were active and could be visualized if required at any time. Depended on his need the situation officer could show or hide the surveillance balloon’s sensor footprint which was coloured blue. The video stream of this sensor could be observed on the vertical monitor and hat to be activated by a pen click into the sensor’s footprint. The video stream of LEXXXWAR tracks could also be observed on the vertical monitor and was activated by a pen click on the tactical symbol of the LEXXXWAR track which was associated to. Figure 8 shows the situation officer and his assistant staff member working at the Digital Map & Situation Surface.

![Figure 8. Working at the Digital Map & Situation Table. In the front the surveillance balloon footprint.](image)
All data could be visualized on the table as described above. The Fovea-Tablett® could be used as a tool to see local high
precise data information and also to separate tactical symbols which fuse to on symbol bunch on the table’s display.
Disconnecting the Fovea-Tablett® from the table’s view allowed working on a scene detail without disturbing the
common overview on the table. Additionally it was possible to take the disconnected tablet to other workspaces in the
operational centre.

Beside a lot of different workspaces in the operational cell also a media wall was positioned. On this wall information
were projected which were for most stuff members of high interest. With help of the projection functionality each
display view (table, vertical monitor or Fovea-Tablett®) of the Digital Map & Situation Table could be projected onto the
media wall.

3.3.1 Workflow and Experience

Two trials were carried out daily; one in the morning and one in the afternoon. At the beginning of each trial a briefing
took place. Because the operation centre’s stuff consisted of many people the first briefing was carried out at the media
wall. The map view projected on the media wall display was in a step before prepared on the Digital Map & Situation
Table. If necessary, subsets of the stuff were additionally briefed at the Digital Map & Situation Table.

During the trial was running the situation officer executed situation analysis using permanent the Digital Map &
Situation Table’s workspace. To obtain the operational picture he used mainly the situation and track data and in fast
scenarios with terror movements inside the camp he used the also surveillance balloon’s data. Based on the operational
picture the commander of the protection forces acted.

Sometimes the situation officer also used the Fovea-Tablett as a kind of a portable clipboard to take a subset of the
operational picture with him, e.g. to discuss this with other stuff members at their own workspace.

4. CONCLUSION

With the complex tasks of military forces in the today’s mostly asymmetric warfare and the heap of available data and
information situation analysis requires a kind of display which offers an information overview about the whole scene and
detailed information only when needed. This can be reached using a “focus plus context” display. With the Digital Map
& Situation Surface a solution was offered which combines three types of display components: a large horizontal
tabletop display for an scene overview, small scale displays which offer a focus view onto the scene, and a second large
display which is attached perpendicular to the tabletop and provides space for displaying information on objects which
can’t be adequately displayed on the horizontal display.

Between 25th August and 5th September 2008 the TechDemo08 took place in Eckernförde (Germany). TechDemo08 trials
were intended to test new technologies for protecting troops and civilians against terrorist attacks. During the trials a
camp and a harbour had to be protected. Heart of protection was the operational cell where the situation had to be
analysed and the decision of further actions had to be done. Base of situation analysis were reconnaissance data, derived
from airborne, maritime and ground assets. To make fast decisions possible a system network according to the MAJIIC
system architecture was build up.

Placed in the operational cell the Digital Map & Situation Table was the workspace of the situation officer. Beside
detailed maps for the region the following reconnaissance data were available to give an impression about the theatre’s
situation: reports, analysed images, video sequences, tracks which informed about the object movement, also about the
movement of the own forces, situation information derived from reconnaissance data, and real time videos which gave
imaging information about the camp and harbour. During the trial was running the situation officer executed situation
analysis using mainly situation data, track data and the real time video of the surveillance balloon. Depended on the
operational picture which was created by situation officer the camp commander deployed the own forces.
The TechDemo08 showed that the Digital Map & Situation Table offers a good visualization concept so that the situation officer accepted it as a workspace for situation analysis. But it also got obvious that a high acceptance only can be reached if the visualization concept will be added by an interaction concept which enables a seamless interaction between the different displays.

REFERENCES


